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THE INTERPLAY OF INFORMATIVE ASSESSMENT CRITERIA AND CONTINUOUS FEEDBACK WITH MATHEMATICS STUDENTS' LEARNING ORIENTATIONS

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Many researches have suggested that making assessment criteria visible supports learning. On the other hand, others have claimed that too much clarity in assessment criteria and feedback could lead to instrumentalism: superficial observance of criteria without deeper thinking. Due to this ambiguous body of knowledge, we wanted to investigate what type of mathematics learning occurs during a course which provides clear assessment criteria and continuous feedback, combined with a technology enhanced learning environment based on self-assessment and reflection of learning.

BACKGROUND

In the fall semester 2017, one of the authors of this article was giving a course of the didactic of mathematics for pre-service teachers in Helsinki. In the didactic course, students were provided continuous and informative feedback and clear assessment criteria, i.e. detailed descriptions of what type of activities were to be connected to which grade. The students got to choose which grade they were willing to work for. At the beginning of the course, the students and the teacher discussed the criteria and how they were connected to the course's learning goals. According to e.g. Hattie & Timperley (2007), Stefani, Clarke & Littlejohn (2000), Roberts, Park, Brown & Cook (2011) such pedagogy clearly supports learning in a positive way, as it strengthens reflection skills, learner ownership and autonomy. During the course, the students strived for the highest grades and they reached the goals of the course well. They reported that the assessment system was very motivating, clear and fair, and that it pushed them to work harder.

However, some literature (e.g. Hume & Coll, 2009) suggest that students should not be provided with exact information about what to do to gain a specific grade. This idea is further elaborated by Torrance (2007, 2012), who claims that too much transparency, by which he means clarity on learning objectives, could lead to instrumentalism. In that case, the students might just superficially follow the criteria, and use any feedback they receive to mechanically correct their performance instead of really going deeper in their thinking. Morrison & Joan (2002) claim that instrumentalism leads to "teaching the test" perspective. Bloxham & West (2004) describe how over-specification of assessment criteria may narrow down students understanding of learning goals. On the other hand, leaving the assessment criteria unclear doesn't help students (nor the

teacher) to see how the criteria are ought to be met. This way the teacher's power over students may increase, and the student's role becomes again reliant.

This kind of a situation can be avoided by combining the socio-constructivist view of feedback with the cognitive view (Evans, 2013). In her article, Evans made a thematic analysis of assessment feedback in higher education. She embraces the tensions of beneficial and not so beneficial assessment feedback practices, but provides also an extensive list of the attributes that have been proved to make continuous feedback useful. In her list, effective assessment feedback a) is ongoing and an integral part of assessment, b) is explicitly guided, c) emphasises feed-forward instead of *feedback*, d) engages students in and with the process, e) attends to support learning, not personal attributes, and f) involves training in assessment feedback as an integral part.

Despite the claimed benefits of feedback, there might be challenges in pedagogies that allow students to set their grade goals in advance, expect teachers to define the criteria to each grade and finally wait students to perform certain tasks to achieve the criteria. This might weaken students' ability to set useful learning tasks themselves and to identify the depth and connections of the tasks (Torrance, 2011, 2007; Hume & Coll, 2009; Evans, 2013), leading to instrumentalism. In Torrance's (2007, p. 282) words: "transparency of objectives coupled with extensive use of coaching and practice to help learners meet them is in danger of removing the challenge of learning and reducing the quality and validity of outcomes achieved."

How to measure whether learning has occurred 'deeply' or through some kind of instrumentalism? In this article we conceptualize different learning styles with the concept of learning approaches. They have been broadly divided into 'deep' and 'surface' learning approaches by, for example, Biggs (1987, 2012) and Entwistle (1991). As deep approach refers to an intention to truly understand the topic to be learned with an intrinsic motivation (Diseth, 2003), surface approach is linked with the intention to complete the task and not so much with the intention to grow as a learner (Biggs, 1987). These two approaches model the diversity of different learner orientations in our course context.

To avoid instrumentalism, we should know what is in the other end of the continuum. Are deep learning approach and instrumentalism opposites? Can learning turn deep, if it is guided by specific instructions, constructed mainly by someone else?

THE DIGITAL SELF-ASSESSMENT PROJECT

In the Department of Mathematics and Statistics in the University of Helsinki, teachers in first-year courses have started to emphasise clarity in assessment criteria combined with continuous feedback and extensive student autonomy. By these means, they wish to elicit deeper and more complex thinking. The Digital Self-Assessment (DISA) model aims to create a digital assessment model for large university level courses, based on self-assessment. The model seeks to encourage students to constantly reflect on their own learning and take more responsibility for it.

In the DISA model, students receive extensive feedback from teachers, peers, themselves and a software designed specifically for the course model. The assessment criteria are made visible and transparent through a learning objectives matrix. The aim of the model is to support student autonomy, motivation and depth of learning, as well as their self-regulation and reflection skills. The model can be used in teaching large courses, and it has been piloted in two mathematics courses (Linear algebra and matrices, two instances, 130 and 400 participants, respectively).

Each week, students were given a set of problems to solve. For digital tasks, instant automatic feedback was offered. Others were manual tasks completed with pen and paper. For a subset of the manual coursework, the students received written comments from the teachers or peers. For solving the problems, students were offered guidance by peer tutors in drop-in sessions.

Instead of a final exam, the students set their grades themselves at the end of the course via a simple questionnaire, based on the learning objectives matrix. The students assessed their mastering of each topic and awarded themselves a grade for the course. The students were also asked to write down why they chose that specific final grade. Before the final self-assessment, a similar self-assessment was practised twice during the course.

RESEARCH TASK AND RESEARCH QUESTIONS

Our earlier results concerning the DISA model imply that the model supports students in using deep learning approach, and study for themselves, not for an exam (Nieminen, Rämö, Häsä, & Tuohilampi, 2017). Bearing in mind Torrance's (2007, 2012) critique, we became interested in investigating how the assessment criteria and continuous feedback interact with students' learning. The exact research questions of this study are:

1. How do deep learning and surface learning orientations distribute across the students taught with the DISA model?
2. How did the students perceive the transparent assessment criteria and extensive feedback in the DISA model?

METHOD

After a large first year linear algebra course in the fall 2017 with a little over 400 participants, a digital survey was conducted. The course was part of a comparative DISA research project, so the participants were divided into two groups: approximately 200 hundred students participated in a regular course exam while 183 students set their own course grade with a digital self-assessment sheet. The data used in this paper consists of the survey data for those in the self-assessment group who answered the survey and gave their permission to use the data in research ($n = 155$).

The survey consisted of qualitative and quantitative questions. Deep and surface learning approaches were tested with a validated questionnaire from the HowULearn

project (Parpala, Lindblom-Ylänne, Komulainen, & Entwistle, 2013), both consisting of four items ($\alpha = .76$ and $\alpha = .75$) on a 5-Likert scale. The open ended questions concerned the student perceptions on the assessment methods in the DISA model; the questions were based on the interview questions by Mumm and colleagues (2015).

To create student profiles based on the reported levels of deep and surface learning approaches, a cluster analysis was conducted. Based on our previous study (Nieminen et al., 2017) we used a solution of clusters as a base for k-means-analysis with an Euclidean distance. Ward's algorithm was chosen for clustering algorithm to decrease the differences among the clusters, and the scores of the variables were standardized to Z-points before the analysis.

To describe how instrumentalism and deep learning were perceived by the students, a qualitative content analysis (QCA) was conducted, based on the model of Schreier (2012). First, a coding frame was created so that only the answers concerning the perceptions on transparent assessment criteria and extensive feedback were selected. This resulted into 166 analysis units consisting of single answers. These open answers were then divided into three categories; those concerning some kind of an 'instrumentalism' of learning and those concerning 'deep learning', and those concerning both of these. This phase was heavily influenced by the researcher's earlier knowledge about these concepts. Finally, a data-driven QCA was conducted to all these three categories.

RESULTS

How do deep learning and surface learning orientations distribute across the students taught with the DISA model?

Deep learning approach ($M = 3.83$, $SD = .72$) was reported to be higher than surface learning approach ($M = 2.22$, $SD = .81$) after the course ($t(153) = 27.83$, $p = .000$).

The results of the cluster analysis are shown in Table 1.

Cluster	N	Deep learning approach		Surface learning approach	
		Mean	Std. Dev.	Mean	Std. Dev.
1	24	3.05	.48	1.71	.45
2	15	2.80	.58	3.60	0.67
3	51	3.84	.45	2.76	.40
4	64	4.36	.41	1.66	.40
Total	154	3.83	.72	2.22	.81

Table 1: Mean values of surface learning and deep learning in four clusters.

The four clusters were named according to their features: 1) Little surface oriented and little deep oriented learning (*disoriented*), 2) A lot of surface oriented and little deep oriented learning (*surface approach orientation*), 3) A lot of deep oriented as well as

surface oriented learning (*mixed orientation*), 4) A lot of deep oriented and little surface oriented learning (*deep approach orientation*).

How did the students perceive the transparent assessment criteria and extensive feedback in the DISA model?

The data analysis with QCA resulted in three different categories: 1) instrumentalism, 2) deep learning and 3) mixed perceptions. Here we present each category with citations from the data; all the citations are marked with brackets showing the learning approach cluster in which the respondent belongs to. This is done to further describe the cluster formation.

The answers of the students that reflected some sort of instrumentalism also reflected untrained reflection skills. These kinds of answers dealt primarily with extensive feedback and not that much with transparent learning objectives. Although self-assessment as a method was used precisely to enhance reflection (see Nieminen et al., 2017), the extensive feedback supporting it was sometimes seen as something that guides but that does not encourage to deepen the understanding on your own learning. Some students felt that the feedback only ‘pointed out your own mistakes’ as these examples show:

They [assessment methods] did not particularly support learning but perhaps gave a better idea of what to practice more. (cluster 2)

Self-assessment is also useful, since the objective assessment of yourself is hard, but it’s useful, so that you know how to put your energy into learning the right things. (cluster 4)

In our data, hurry was seen as a cause of instrumentalism. Hurry was also seen as something that reduced the power of our learning environment designed to enhance reflection. The next quote from the data is an example of this:

Now, however, I was worried about how I could show my excellent skills in the course without doing a lot of tasks. When there was a huge amount of other courses and submissions alongside, there was no time left for the tasks. . . The exam would have been much easier and it would have been a lot less work for me. (cluster 4)

On the other hand, some of the answers were coded as representing some kind of a deep approach to learning. In these answers formative, extensive assessment methods were seen as something that enabled a deeper approach to learning. Feedback received from various sources was linked to building an image of yourself as a learner. Two of the respondents described their learning as follows:

Self-assessment helped me to reflect on myself as a learner of mathematics. (cluster 4)

I also liked that the teaching assistant did not directly say the answer, but asked auxiliary questions or said remarks, so that I could realise how to solve a task and learn this way. (cluster 4)

Students sought for objectivity as they gained feedback on their own learning; this was clearly seen in the answers that reflected a deep learning approach. Transparent

learning matrix helped the students to form their own personal goals, as is seen in the answer of one of the respondents:

Being in the self-assessment group motivated to be more aware of your own goals and the work you had done than before. (cluster 4)

Self-assessment makes it possible and maybe even forces you to consider your own skills. Then you have to face your level of expertise and take a stand on it. When you know what you are capable of and should be capable of, you can set your own goals and strive for them effectively. (cluster 4)

The answers that were coded to represent both instrumentalism and deeper learning shed more light on the issue. Some of the students described reflective and deep learning in their answers, yet the same answers showed elements of instrumentalism too. This data is not deep enough to examine the level of reflection behind these comments; that would require, for example, student interviews. It does, however, cast some light on cluster number 3 of our analysis, that represents the students that make use of both deep and surface learning approach. The complicated connection of instrumentalist learning and the motivation to truly understand the content of the course is seen in the comment below:

Thanks to self-assessment, I have had a very strong motivation to make as many tasks as possible and to understand things as well as possible. In addition, self-assessments have made it clear what needs to be learned during the course and what needs improvement. On the other hand, self-assessing the grade for the course has created some pressure on taking the course. (cluster 3)

CONCLUSIONS

Four clusters with different learning orientations were found in the student group studying according to the DISA model. There were two groups with ambiguous orientations (disoriented and mixed orientations), one with lots of surface orientation and one with lots of deep learning. The latter one was clearly the one having the greatest number of students. All in all, deep learning orientation was remarkably more present in students' answers than surface orientation.

These results imply that students do not perceive surface learning and deep learning as mutually exclusive. The students also seem to focus on the what question of learning (knowledge) instead of a more holistic picture, even though still having deep learning orientation. Thus, clarity in assessment criteria might not be evidently good or bad. Our results support its use with careful consideration, allowing students to be active in the construction of knowledge (see Hume & Coll, 2009). Students should not become reliant of the teacher's specifications, while teachers should not turn their attention to provide evidence for meeting the criteria, instead, a combination of the socio-constructivist and the cognitive view of feedback should be used (Evans, 2013).

According to our qualitative data, the students in the first year mathematics course have trouble with "knowing what they know". This might imply that clear assessment

criteria are especially useful in forming deeper kind of learning in this context; university mathematics is a new kind of a context for most of the students in this first year course. Also, personalized and formative feedback was perceived as an important form of support, as was the case, with, for example, Roberts, Park, Brown & Cook (2011). These results show ‘instrumentalism’ in a different light, since it can be seen as something that is required for deeper understanding of university mathematics to form.

Before the course, we tried to ensure that all the feedback was to support and guide learning during the class, but this was not always the case. Some students felt that extensive feedback was represented the ‘true’ level of learning. We intended that this feedback was supposed to be used as a base for further reflection. However, whether it is formative, extensive assessment that leads to this kind of possible *assessment as learning*, as Torrance (2007) suggests, is questionable, since the same formative assessment is also seen as crucial for deep learning to strive in our data. We could identify mechanisms of deep learning basing on performing the tasks following carefully described learning goals. Further, definitions of feedback often include or even require the idea of bridging the gap between desired and actual performance (Evans, 2013). This definition entails the desired performance exactly defined.

Torrance (2007) suggested that the core of instrumentalism is establishing transparent criteria for a course and then providing information about how the students can meet these criteria. In the DISA model, student autonomy is supported by letting the students to do the assessment by themselves, with support of extensive feedback. Is this autonomy the key to transform instrumental learning into deeper kind of understanding? In our model, student reflection is promoted, so that students would not just take the learning criteria as given but rather explore them with a critical view. Students in the model are expected to take more responsibility on their own learning. However, as the clustered learning orientations imply, an idea of learning as ‘an act of social and intellectual development’ (Torrance, 2007, p. 293) is not always reached in our model. Further analysis is needed to investigate the mechanisms connecting deep learning and instrumentalism in the field of learning mathematics. One has to ask how useful is the idea of setting instrumentalism and deep learning on the same continuum?

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